



A revision of the spirit loaches, genus *Lepidocephalus* (Cypriniformes, Cobitidae)

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Abstract

Lepidocephalus has been assumed to include only two species and confined to peninsular Malaysia and Indonesia. However, based on records and collections reported herein, the genus contains five species and is most common in the Chao Phraya basin of Thailand. Large rivers seem to be the preferred habitat, and difficulty in collecting these rivers may account for the paucity of specimens in collections. The known range of these five species includes western and southern Borneo, Java, Sumatra, peninsular Malaysia, and central Thailand.

Key words: Teleostei, Southeast Asia, *Lepidocephalichthys*, *Lepidocephalus nanensis*

Introduction

Recent publications (Roberts, 1989; Šlechtová *et al.* 2008; Havird and Page, 2010; Havird *et al.* 2010; Kottelat, 2012), have recognized only two species of *Lepidocephalus*: *L. macrochir* (Bleeker 1854), described from the confluence of Lamatang and Enim rivers at Palembang in eastern Sumatra and the Pepeh River at Surakarta in central Java; and *L. spectrum* Roberts 1989, described from Sungai Melawi near its confluence with Kapuas River, near Sintang, western Kalimantan. *Lepidocephalichthys pallens* Vaillant 1902, described from the Kapuas River, western Kalimantan, and *Acanthopthalmus pahangensis* de Beaufort 1933, from the Pahang River, at Mentakab, peninsular Malaysia, have been considered synonyms of *L. macrochir*. However, based on examination of holotypes, both are valid species easily distinguished from *L. macrochir* and *L. spectrum*. Recent collections in the Chao Phraya basin in Thailand have resulted in the discovery of a fifth species, described herein. The objectives of the study were to diagnose valid species of *Lepidocephalus* and describe their geographic distributions based on available specimens.

Material and methods

All specimens known to us and available for study were examined. Measurements and counts follow Armbruster (2012), except prepelvic and preanal lengths were measured as the greatest straight-line distance between the tip of the snout and the origin of the first pelvic- or anal-fin ray. The posterior two rays of the dorsal and anal fins are branches of the same ray that unite internally and are counted as one. Lengths were measured to the nearest 0.1 mm using digital calipers and were taken from the left side of the specimen when possible. Paired fin-ray counts were recorded as the total number of unbranched and branched rays. Barbel lengths were measured with barbels extended posteriorly from the base in a straight line.

Scales on *Lepidocephalus* are extremely small, embedded in the dermis to varying degrees, and difficult to count. For some specimens and species, counts are given for scales along the lateral line; for others, counts are given for lateral-line pores, which often are easier to count than scales.

All specimens examined were over 35 mm standard length (SL) and assumed to be sexually mature. The sex of

a previously dissected specimen was verified by examining gonads. Other specimens were assumed to be a males if they had a lamina circularis, or a females if they lacked a lamina circularis. Institutional catalog numbers for specimens examined are followed by numbers and standard lengths of specimens, in mm, in parentheses. Institutional abbreviations follow Fricke and Eschmeyer (2013).

Common names in English could not be found for any species of *Lepidocephalus*. Spirit loaches was chosen in recognition of the phantom-like appearance of these fishes; all species seem to live in deep dark riverine habitats. Common names are used routinely by aquarists and the general public.

***Lepidocephalus* Bleeker 1858**

Lepidocephalus Bleeker 1858:303. Type species: *Cobitis macrochir* Bleeker, 1854 designated by Bleeker 1863a:38 and 1863b:4.

Diagnosis. Cobitid with lateral line complete; dorsal-fin origin over or behind pelvic-fin origin; deep, slab-sided body; scales on top of head (except *L. pahangensis*), cheek and opercle; eye very small and subcutaneous, or absent; 8–9 branched dorsal-fin rays; 9–13 pectoral-fin rays; 6–8 pelvic-fin rays; 42–43 vertebrae; lamina circularis a thickened 2nd ray of pectoral fin on mature male.

Most often confused with *Lepidocephalichthys* and *Pangio*. *Lepidocephalus* differs from *Lepidocephalichthys* in having complete lateral line (vs. no lateral line); eye very small and subcutaneous, or absent (vs. eye present, not conspicuously small); 8–9 (vs. 6) branched dorsal-fin rays; 9–13 (vs. 7) pectoral-fin rays; longer predorsal length, (>60% SL vs. ~50–55%); and lamina circularis of mature male on 2nd ray (vs. 7th and 8th rays) of pectoral fin (Havird *et al.* 2010). They also differ in numbers of total vertebrae (among species for which data are available) with *Lepidocephalus* having 42–43, and *Lepidocephalichthys* having 35–38 (Roberts 1989:96). All species of *Lepidocephalus* except *L. pahangensis*, have scales on top of head (vs. scales absent on top of head in *Lepidocephalichthys* except in *L. kranos* and *L. irrorata*), and on the cheek and opercle (vs. scales usually absent or deeply embedded on cheek and opercle in *Lepidocephalichthys*).

Lepidocephalus differs from *Pangio* in having scales on cheek and opercle (vs. no scales on head); complete lateral line (vs. no lateral line); eye very small and subcutaneous, or absent (vs. eye present, not so conspicuously small); 8–9 (vs. 5–6) branched dorsal-fin rays; and 6–8 (vs. 5–7) pelvic-fin rays (Havird *et al.* 2010). *Lepidocephalus* has 42–43 total vertebrae (among species for which data are available), and *Pangio* has 45–71 total vertebrae (Roberts 1989:96, as species of *Acanthophthalmus*).

In general appearance, *Lepidocephalus* is deep-bodied and slab-sided, and is readily distinguishable from *Lepidocephalichthys*, which is more slender and much less slab-sided, and *Pangio*, which is long, slender and generally eel-like in appearance.

Based on nuclear gene data, Šlechtová *et al.* (2008) hypothesized *Lepidocephalus* to be closely related to *Canthophrys gongata* (Hamilton 1822), a species native to India, Nepal, Burma, Bangladesh and Pakistan (Shrestha, 2008; Talwar and Jhingran, 1991). However, there is no morphological evidence to suggest a close relationship between *Lepidocephalus* and *Canthophrys*. Species of *Lepidocephalus* differ greatly from *Canthophrys gongata* in general appearance, and lack the pattern of black dorsal saddles and black spots on the side of the body and the wide depressed head with large upwardly directed eyes. They also differ in having the lamina circularis on the 2nd ray (vs. medial rays) of the pectoral fin, and in having (vs. lacking) scales on the head.

***Lepidocephalus macrochir* (Bleeker, 1854)**

Indonesian Spirit Loach

(Fig. 1B)

Cobitis macrochir Bleeker, 1854:97. Type-locality: Java (Surakarta) in fluviis; Sumatra (Palembang) ubi confluent flumina Lematang et Enim. [Confluence of Lematang and Enim rivers, Palembang, eastern Sumatra; Pepeh River, Surakarta, central Java, Indonesia]. Syntypes: originally 5; only BMNH 1866.5.2.55 known.

Lepidocephalus macrochir.—Bleeker, 1860:70.

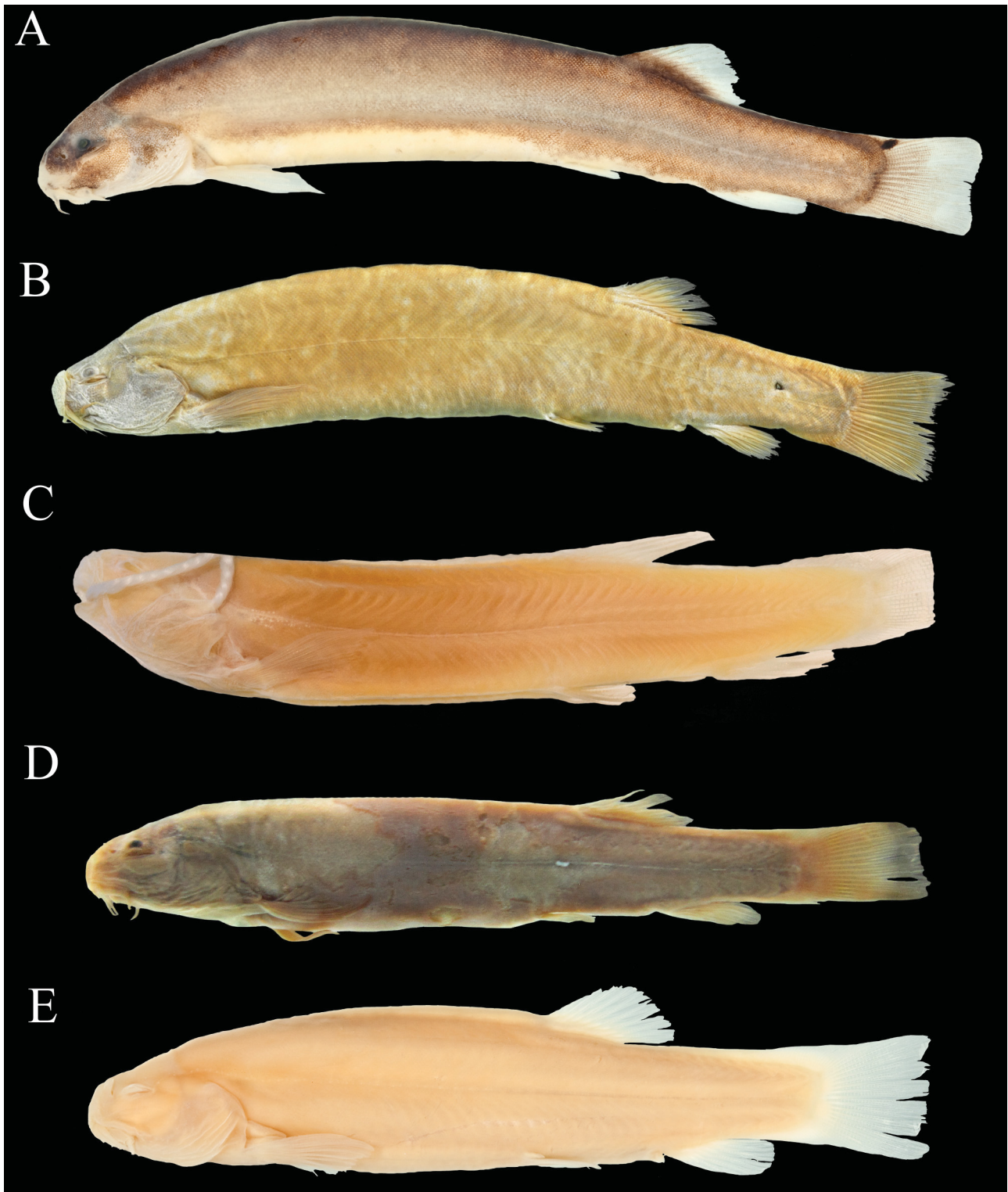


FIGURE 1. Species of *Lepidocephalus*. (A) *L. nanensis*, holotype, NIFI 4388, 72.0 mm SL, Nan River, Thailand; (B) *L. macrochir*, syntype, BMNH 1866.5.2.55, 77.7 mm SL, Sumatra or Java; (C) *L. pallens*, holotype, RMNH 7783, 41.9 mm SL; (D) *L. pahangensis*, holotype, ZRC 490, 35.8 mm SL; (E) *L. spectrum*, paratype, USNM 230267, 49.2 mm SL, Kalimantan. Photos A, C, D and E by Z. Randall; B by M. Sabaj Perez.

Diagnosis. A species of *Lepidocephalus* that is readily distinguishable (Fig. 1, Table 1) from *L. spectrum* by the presence of eyes and dark pigment on the body, and absence of tubules along the lateral line; from *L. pahangensis* by the presence of scales on top of the head; from *L. pallens* by having the dorsal-fin origin well behind (vs. over) the pelvic-fin origin (predorsal length 65.0–69.3 vs. 59.9% SL); and from *L. nanensis* by having a shorter snout (3.9–5.1 vs. 5.6–7.4% SL; 23.3–27.1 vs. 28.6–38.1% HL). *Lepidocephalus macrochir* further differs from *L.*

pahangensis in having 8 (vs. 9) branched dorsal-fin rays and 5–6 (vs. 4) branched anal-fin rays, and from *L. pallens*, *L. pahangensis* and *L. spectrum* in having a shorter head (16.6–18.8 vs. 23.2, 21.8, and 21.3–23.2% SL, respectively).

Description. Body deep, slab-sided; greatest depth 15.7–18.9% SL. Head narrow, length 16.6–18.8% SL. Eye small, in dorsal half of head in shallow depression above bifid suborbital spine. Origin of dorsal fin behind origin of pelvic fin. Small axillary lobe on pelvic fin; small fleshy lobe at origin of pectoral fin. Pectoral fin falcate.

Scales on top of head, cheek and opercle; body completely covered with minute, often deeply embedded scales. Lateral line complete, 105–150 pores; no tubules on lateral line. Mouth horseshoe-shaped; upper lip without median indentation; lower lip with median indentation on lower edge. Two pairs of rostral barbels; inner pair reaching to corner of mouth, outer pair slightly longer and reaching slightly past corner of mouth; one pair of maxillary barbels, reaching approximately to vertical at posterior end of groove containing suborbital spine. Large flap on anterior nostril. Dorsal rays iii,8; pectoral rays 10–11; pelvic rays 6–8; anal rays ii,5–6; upper branched caudal rays 7–8; lower branched caudal rays 7.

Coloration. Described by Bleeker (1854) as “colore corpore pinnisque fusciscentis-aurantiaco vel fusco; maculis vel vittis corpore pinnisque nullis,” which translates to: body and fins brown-orange or brown tinged with grayish-black; lacking spots or bands on body and fins.

Distribution. *Lepidocephalus macrochir* is poorly represented in collections and known only from the Lamatang and Enim rivers in eastern Sumatra, the Pepeh River in central Java, and the Barito River basin in southern Borneo (Fig. 2). Previous reports of the distribution that included peninsular Malaysia and western Borneo (e.g., Roberts, 1989) were based on the holotypes of *L. pahangensis*, and *L. pallens*, respectively. The occurrence of *L. macrochir* in the Barito River basin in southern Borneo and the Pepeh River in central Java supports the hypothesis of de Bruyn *et al.* (2013) of a paleo East Sunda River basin connecting these land masses.

***Lepidocephalus nanensis*, n. sp.**

Thai Spirit Loach

(Fig. 1A)

Holotype. NIFI 4388, 72.0 mm SL; Thailand, Phitsanulok Prov., Khlong Chompu, Mae Nam Nan, Chao Phraya basin, Nov. 2008, G. Deen.

Paratypes. NIFI 3787, 79.3 mm SL; Thailand, Phitsanulok Prov., Nern Ma Prang District, Mae Nam Nan drainage, Chao Phraya basin, Nov. 2008; NIFI 4856 (6, 69.9–76.1), Phitsanulok Province, Bang Rakam District, Mae Nam Nan, 16.76N,100.11E, 9 Feb. 2011; NIFI 4857 (6, 68.4–80.1), boundary of Sukhothai Province, Kongkrait District with Phitsanulok Province, Prompiram and Bang Rakam districts, Mae Nam Nan, 16.76N, 100.11E, 18 Aug. 2010; NIFI 4858 (4, 56.4–67.6) Nakon Sawan Province, Chum Sang District, Borraped Lake, 15.71N,100.27E, 11 Oct. 2010; UF 186928 (5, 68.2–75.0), Phitsanulok Province, Prompiram District, Mae Nam Nan near Naraesuan Dam, 17.04N,100.20E, 23 Apr. 2009; UF 186929 (2, 65.5–72.7), Phichit Province, Sam Ngam District, Mae Nam Nan, 16.50N,100.20E, 4 Oct. 2011; UF 186930 (2, 65.2–70.0), Nakon Sawan Province, Krok Pra District, Chao Phraya River, below confluence of Nan and Yom rivers, 15.55N,100.08E, 15 Jun. 2009.

Diagnosis. A species of *Lepidocephalus* that is readily distinguishable (Fig. 1, Table 1) from *L. spectrum* by the presence of eyes and dark pigment on the body, and absence of tubules along the lateral line and large papillae on the lips; from *L. pahangensis* by the presence of scales on top of the head and absence of large papillae on the lips (Figs. 3A, 4A); from *L. pallens* by having the dorsal-fin origin well behind (vs. over) the pelvic-fin origin (predorsal length 68.1–71.3 vs. 59.9% SL); and from *L. macrochir* by having a longer snout (5.6–7.4 vs. 3.9–5.1% SL; 28.6–38.1 vs. 23.3–27.1% HL).

Description. Body deep, slab-sided; greatest depth 14.7–21.2% SL. Head narrow, length 16.9–22.2% SL. Eye small, in dorsal half of head in shallow depression above bifid suborbital spine. Origin of dorsal fin behind origin of pelvic fin. No or small axillary lobe on pelvic fin; absent on holotype. Fleshy lobe at origin of pectoral fin.

Scales on top of head, cheek and opercle; body completely covered with minute, often deeply embedded scales. Lateral line complete, 185–205 scales; 0–2 pores on caudal fin; no tubules on lateral line.

Mouth horseshoe-shaped; upper lip smooth on ventral surface, with small papilla on anterior and posterior margins, without median indentation; lower lip plicated, with median indentation on lower edge (Figs. 3A, 4A).

Two pairs of rostral barbels; inner pair reaching to corner of mouth, outer pair slightly longer and reaching slightly past corner of mouth; one pair of maxillary barbels, reaching approximately to vertical at posterior end of groove containing suborbital spine. Large flap on anterior nostril. Dorsal rays iii,8; pectoral rays 9–11; pelvic rays 6–8; anal rays ii,5–6; upper branched caudal rays 7; lower branched caudal rays 7.

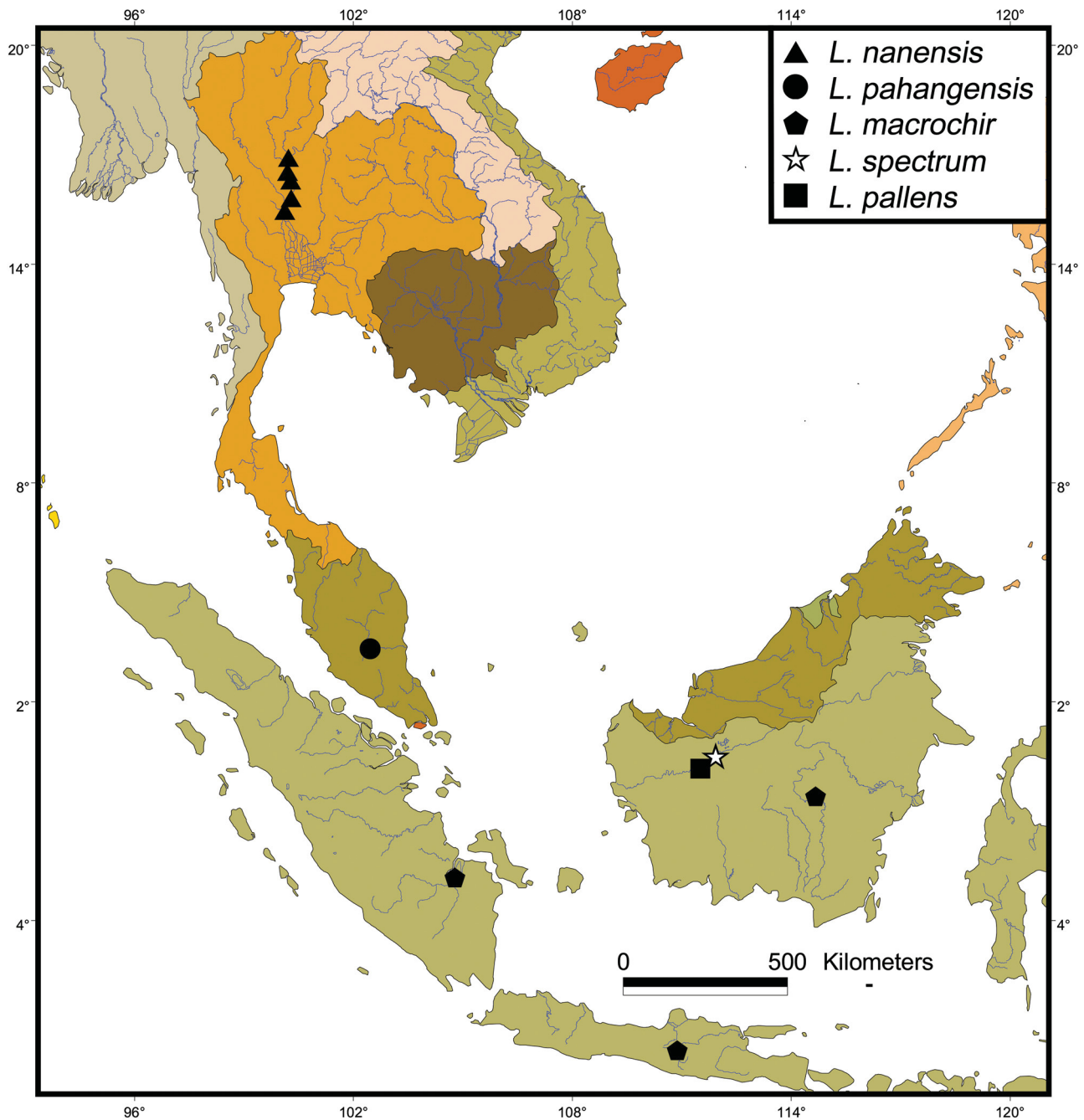


FIGURE 2. Distribution of specimens of *Lepidocephalus* examined.

Cephalic lateralis system: lateral canal with 1 pore, extends anteriorly from lateral line; suborbital canal extends along lower margin of groove holding suborbital spine with 4 pores, abruptly turns anteroventrally with 4 more pores, ends on side of snout well in front of nostrils; no supraorbital canal at surface. Supratemporal canal branches off lateral canal, then ends or continues under skin without pores at surface. Preoperculomandibular pores not visible.

Pectoral fin falcate in both sexes; second ray longer in both sexes than other pectoral-fin rays. Pectoral fin much longer in some individuals than others (12.2–18.9% SL); extent and significance of inter- and intra-variation,

including sexual and ontogenetic variation, is unknown. Second ray of pectoral fin much thicker (forming lamina circularis) in adult male than in female, but not longer. Pectoral fins of male *L. nanensis* (N = 4) averaged 15.1% SL; those of females (N = 7) averaged 15.5% SL. The thickened ray presumably has a function related to spawning behavior. Pelvic fins are short, 6–8% SL.

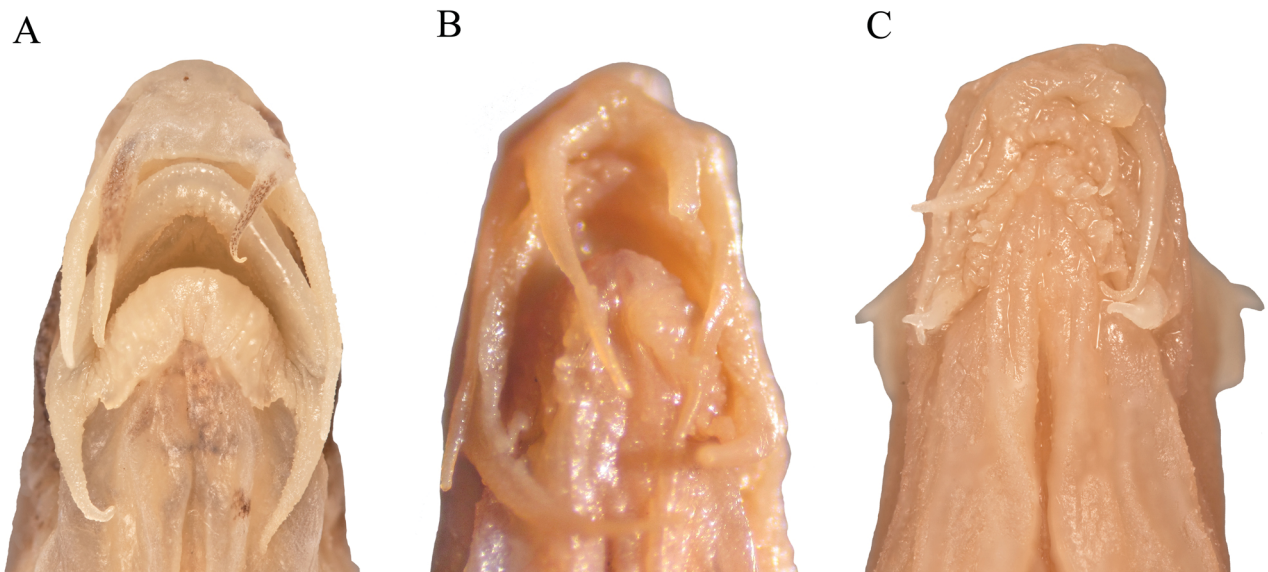


FIGURE 3. Mouths of *Lepidocephalus*. (A) *L. nanensis*, holotype, NIFI 4388, 72.0 mm SL, Nan River, Thailand; (B) *L. pahangensis*, holotype, ZRC 490, 35.8 mm SL; (C) *L. spectrum*, paratype, USNM 230267, 49.2 mm SL, Kalimantan. Photos by Z. Randall.

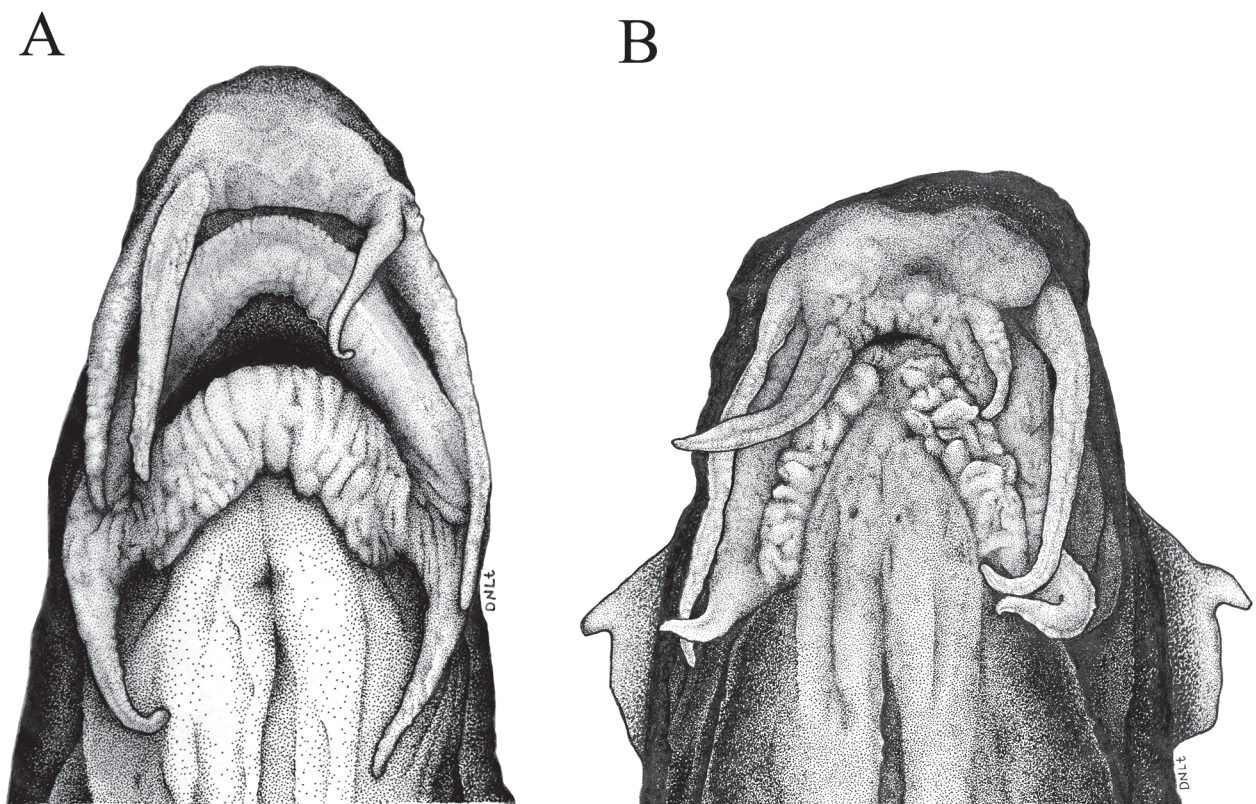


FIGURE 4. Mouths of specimens of *Lepidocephalus* shown in Figure 3. (A) *L. nanensis*, (B) *L. spectrum*. Although the lower lip of *L. nanensis* is folded more posteriorly than that of *L. spectrum*, it and the upper lip lack the large papillae shown on the lips of *L. spectrum*. Drawings by D. Lumbantobing.



FIGURE 5. *Lepidocephalus nanensis* in an aquarium. Collected at Naraesuan Dam on Mae Nam Nan, Prompiram District, Phitsanulok Province, Thailand, June 2005 (not voucher). Photo by N. Panitvong.

Coloration in life. Body dusky pink-brown; darker gray-brown along mid-dorsum and along mid-side posteriorly (Fig. 5). Distinctive yellow snout followed by blue-black bar before eye; head dusky yellow behind eye. Cheek and opercle with silver-blue iridescence. Dorsal fin with concentration of melanophores at base, creating dark basal band - deepest anteriorly; melanophores outlining lower halves of fin rays. Other fins clear except for melanophores along rays.

Etymology. The name *nanensis*, an adjective, refers to the river system where most specimens have been collected.

Distribution. *Lepidocephalus nanensis* is found in Thailand in the Nan River and in the Chao-Phraya River below the confluence of the Nan and Yom rivers (Fig. 2). To our knowledge, Šlechtová *et al.* (2008) first recorded this species from Thailand (as *L. macrochir*) and included molecular data from specimens collected at a fishpond at Nakom Savan (Nakon Sawan, Nakon Sawan Province), Thailand. Recent collections suggest that this species is common in the Nan and lower Chao Phraya rivers. These large rivers seem to be the preferred habitat of the species.

***Lepidocephalus pallens* (Vaillant, 1902)**

Pallid Spirit Loach

(Fig. 1C)

Lepidocephalichthys pallens Vaillant, 1902:153. Type locality "Bords du Kapoeas (Sintang?)" [Kapuas River (at Sintang?)]. Holotype: RMNH 7783.

Diagnosis. A species of *Lepidocephalus* that is readily distinguishable (Fig. 1, Table 1) from all other species of *Lepidocephalus* by having the dorsal-fin origin over the pelvic-fin origin (vs. dorsal-fin origin behind the pelvic-fin origin), and a concomitantly shorter predorsal length (59.9 vs. 62.4–71.3% SL). *Lepidocephalus pallens* further differs from *L. pahangensis* in having scales on top of the head, and from *L. spectrum* by the presence of eyes and darker pigment on the body, and absence of tubules along the lateral line.

Description. Body deep, slab-sided; greatest depth 17.4% SL. Head narrow, length 23.2% SL. Eye small, in dorsal half of head in shallow depression above bifid suborbital spine. Origin of dorsal fin over origin of pelvic fin. No axillary lobe on pelvic fin. Small fleshy lobe at origin of pectoral fin.

Scales on top of head, cheek and opercle; body completely covered with minute, partially embedded scales. Lateral line complete, ~200 scales along lateral line; no tubules along lateral line. Mouth horseshoe-shaped; upper

lip without median indentation; lower lip with median indentation on lower edge. Two pairs of rostral barbels; inner pair reaching to corner of mouth, outer pair slightly longer and reaching slightly past corner of mouth; one pair of maxillary barbels, reaching approximately to vertical at posterior end of groove containing suborbital spine. Large flap on anterior nostril. Dorsal rays iii,8; pectoral rays 11; pelvic rays 7; anal rays ii,5; upper branched caudal rays 7; lower branched caudal rays 7; vertebrae 28 abdominal + 15 caudal = 43 total (Roberts 1989:96).

Only specimen known is the holotype, which appears to be a female. The pectoral fin is falcate with the 2nd ray longer but not thicker than other rays (20.0% SL). Pelvic fin small, but larger than in other species at 11.5% SL.

Coloration in life. Described as pallid by Vaillant (1902).

Distribution. Known only from the type locality, the Kapuas River presumably at Sintang (Fig. 2).

Remarks. Roberts (1989) treated *L. pallens* as a synonym of *L. macrochir*. However, as noted above, the two species are easily distinguished by the position of the dorsal-fin origin relative to that of the pelvic-fin origin (Fig. 1). *Lepidocephalus pallens* and *L. spectrum* were both described from the Kapuas River in Borneo, and possibly occur syntopically.

***Lepidocephalus pahangensis* (de Beaufort, 1933)**

Pahang Spirit Loach

(Fig. 1D)

Acanthophtalmus pahangensis de Beaufort, 1933:31. Type locality: off Mentakab, Pahang, Pahang River, Malay Peninsula. Holotype ZRC 490; see Hora (1941:55–56) and Alfred (1970:70).

Diagnosis. A species of *Lepidocephalus* that is readily distinguishable (Fig. 1, Table 1) from all other species of *Lepidocephalus* by the absence of scales on top of the head. It is further distinguished from *L. spectrum* by the presence of eyes and dark pigment on the body, and absence of tubules along the lateral line; from *L. pallens* by having the dorsal-fin origin well behind (vs. over) the pelvic-fin origin (predorsal length 68.2 vs. 59.9% SL); from *L. nanensis* by having large papillae on the lips (Fig. 3B); and from *L. macrochir* by having a longer head (21.8 vs. 16.6–18.8% SL). Although counts for *L. pahangensis* are available only for the holotype, it differs from all other species in having 4 (vs. 5–6) branched anal-fin rays, and from all except *L. spectrum* in having 9 (vs. 8) branched dorsal-fin rays.

Description. Body deep, slab-sided; greatest depth 17.0% SL. Head narrow, length 21.8% SL. Eye small, in dorsal half of head in shallow depression above bifid suborbital spine. Origin of dorsal fin behind origin of pelvic fin. Small axillary lobe on pelvic fin. Large fleshy lobe at origin of pectoral fin.

No scales on top of head; scales present on cheek and opercle; body completely covered with minute, partially embedded scales. Lateral line complete, 174 pores along lateral line, 6 pores on caudal fin; no tubules on lateral line. Mouth horseshoe-shaped; lips with large papillae on outer surfaces; upper lip without indentation; lower lip with median indentation on lower edge (Fig. 3B). Two pairs of rostral barbels; inner pair reaching to corner of mouth, outer pair reaching past corner of mouth; one pair of maxillary barbels, reaching approximately to vertical at posterior end of groove containing suborbital spine. Large flap on anterior nostril. Dorsal rays iii,9; pectoral rays 11; pelvic rays 7; anal rays ii,4; upper branched caudal rays 7; lower branched caudal rays 7. Pectoral fin falcate with 2nd ray longer than other rays (15.6% SL), but not thickened. Pelvic fin small, 6.4% SL.

Coloration. Described as being uniformly colored (presumably pinkish gray-brown as in *L. nanensis*) by de Beaufort (1933).

Distribution. Known only from the type locality, the Pahang River at Mentakab, Peninsular Malaysia (Fig. 2).

Remarks. In the original description of *Acanthophtalmus pahangensis*, de Beaufort (1933) described the head as scaleless. The holotype has no scales on top of the head, but has scales on the cheeks and opercles. It seems likely that de Beaufort was referring only to the top of the head in his description, as scales are readily apparent on the cheek and opercle. Hora (1941) examined the holotype and found scales “on the head in the region below and behind the eyes.” Oddly, Hora included a drawing of the head and anterior body of the holotype that differs from his verbal description in showing scales on top of the head as well as on the cheek and opercle. De Beaufort was correct in originally noting the absence of scales on top of the head.

***Lepidocephalus spectrum* Roberts 1989**

Blind Spirit Loach

(Fig. 1E)

Lepidocephalus spectrum Roberts, 1989:106. Type locality: Rocky ledge in middle of Sungai Melawi near confluence with Kapuas mainstream, about 0.5 km upstream from Sintang. Holotype: MZB 3533.

Diagnosis. A species of *Lepidocephalus* that is readily distinguishable (Fig. 1, Table 1) from other all species of *Lepidocephalus* by the absence of eyes, absence of dark pigment on the body, and presence of pored tubules along the lateral line. It further differs from *L. pahangensis* by the presence of scales on top of the head, from *L. pallens* by having the dorsal-fin origin slightly behind (vs. over) the pelvic-fin origin (predorsal length 62.4–65.6 vs. 59.9% SL), from *L. nanensis* by having large papillae on the lips (Figs. 3C, 4B), and from *L. macrochir* by having a longer head (21.3–23.3 vs. 16.6–18.80).

Description. Body deep, slab-sided; greatest depth 18.9–22.1% SL. Head narrow, length 21.3–23.3% SL. Eye absent; small shallow depression above bifid suborbital spine where eye located on other species of *Lepidocephalus*. Origin of dorsal fin slightly behind origin of pelvic fin. Small axillary lobe on pelvic fin. Large fleshy lobe at origin of pectoral fin.

Scales on top of head, cheek and opercle; body completely covered with minute, deeply embedded scales. Lateral line complete, 70–87 pores at ends of ventrally directed tubules along lateral line, 0–2 pores on caudal fin.

Mouth horseshoe-shaped; lips with large papillae on outer surfaces; upper lip without indentation; lower lip with median indentation on lower edge (Figs. 3C, 4B). Two pairs of rostral barbels; inner pair reaching to corner of mouth, outer pair reaching past corner of mouth; one pair of maxillary barbels, reaching approximately to vertical at posterior end of groove containing suborbital spine. Large flap on anterior nostril.

Dorsal rays iii,8–9; pectoral rays 11–13; pelvic rays 6–7; anal rays ii,5–6; upper branched caudal rays 7–8; lower branched caudal rays 7–8; vertebrae 28 abdominal + 14–15 caudal = 42–43 total (Roberts 1989:96). Pectoral fins less falcate than in other species; 2nd ray longer than other rays. Pectoral fin 17.1–18.1% SL; pelvic fin 9.1–12.0% SL.

Coloration. Described by Roberts (1989) as being creamy or pinkish white in life.

Distribution. Kapuas River basin, western Borneo (Fig. 2).

Discussion

Few specimens of *Lepidocephalus* are available for study, and much remains to be learned about the habits and diversity of this group of fishes. They appear to inhabit large rivers and, given their morphology, including the reduction—and in one species—loss of eyes, they probably inhabit deep, dark rivers. *Lepidocephalus nanensis* seems to be common in the Nan-Chao Phraya River basin of Thailand, and perhaps more can be learned there about the ecology and behavior of these interesting fishes. Identifying species, the topic of this paper, should be only the first step. Life histories, and ecological and behavioral studies are badly needed on these and other poorly known loaches.

Lepidocephalus has been assumed to include only two species and confined to peninsular Malaysia and Indonesia. However, the genus contains five species and, based on records reported herein, is most common in the Chao Phraya basin of Thailand. Large rivers seem to be the preferred habitat, and difficulty in collecting these rivers may account for the paucity of specimens in collections.

Lepidocephalus nanensis is very similar to *L. macrochir*, the only difference found being relative snout length. However, this difference plus the large geographic gap between populations is deemed sufficient to separate them, as assumed by Kottelat (2012:33). All specimens of *L. macrochir* available for examination are old; as new samples are obtained the taxonomic decisions made herein can be tested with additional morphological and genetic data – as should be done for many recently described species from Southeast Asia.

Šlechtová *et al.* (2008) examined relationships among 52 species of 16 cobitid genera using the mitochondrial cytochrome *b* gene (cyt *b*) and the nuclear recombination activation gene-1 (RAG-1). Both datasets independently supported a large monophyletic lineage referred to as the ‘northern clade’ that included *Cobitis*, *Iksookimia*, *Niwaella*, *Kichulchoia*, *Koreocobitis*, *Misgurnus*, *Paramisgurnus* and *Sabanejewia*. Genera that fell outside the

northern clade were *Acanthopsoides*, *Acantopsis*, *Canthophrys*, *Kottelatlimia*, *Lepidocephalichthys*, *Lepidocephalus*, *Neoeurirrhichthys* and *Pangio*. These genera did not form a monophyletic group and were referred to as the ‘southern lineages.’ *Lepidocephalus nanensis* (referred to as *macrochir* by Šlechtová *et al.*), the only species of the genus included in the analysis, was found to be sister to *Canthophrys gongata* in the Rag-1 analysis and part of a large polytomy in the cyt *b* analysis. *Lepidocephalus* and *Canthophrys* are very dissimilar morphologically, and a close relationship between these two genera seems unlikely. Genetic data, as well as additional morphological data, are needed to understand intra- and interspecific relationships of *Lepidocephalus*, and to evaluate the current family and genus-level classifications of loaches.

TABLE 1. Characteristics that vary among species of *Lepidocephalus*. Measurements are in mm or percentages of standard length (SL). Range is followed by average in parentheses.

	<i>L. macrochir</i> syntype	<i>L. macrochir</i> Barito River, Borneo	<i>L. nanensis</i>	<i>L. pallens</i>	<i>L. pahangensis</i>	<i>L. spectrum</i>
No. specimens	1	5	28	1	1	3
Standard length	77.7	55.9–69.3 (64.2)	56.4–80.1 (69.6)	41.9	35.8	36.0–57.4 (47.5)
No. dorsal-fin rays	iii,8	iii,8	iii,8	iii,8	iii,9	iii,8–9
No. pectoral-fin rays	10	10–11	9–11	11	11	11–13
No. pelvic-fin rays	6	6–8	6–8	7	7	6–7
No. anal-fin rays	ii,6	ii,5–6	ii,5–6	ii,5	ii,4	ii,5–6
No. branched caudal-fin rays (upper/lower)	8/7	7/7	7/7	7/7	7/7	7–8/7–8
% SL						
Predorsal-fin length	69.1	65.0–69.3 (67.3)	68.1–71.3 (69.3)	59.9	68.2	62.4–65.6 (63.9)
Head length	16.6	16.7–18.8 (18.2)	16.9–22.2 (19.5)	23.2	21.8	21.3–23.3 (22.4)
Snout length	3.9	4.3–5.1 (4.8)	5.6–7.4 (6.6)	6.4	6.4	6.1–6.4 (6.3)
Prepelvic-fin length	--	--	59.7–65.3 (63.4)	61.3	62.8	58.4–60.3 (59.1)
Preanal-fin length	--	--	79.3–84.0 (81.8)	80.2	80.4	76.6–78.9 (77.8)
Greatest body depth	16.7	15.7–18.9 (17.6)	14.7–21.2 (16.8)	17.4	17.0	18.9–22.1 (20.2)
Caudal-peduncle depth	--	--	7.0–10.3 (8.8)	11.0	8.4	10.6–11.8 (11.2)
Pectoral-fin length	--	--	12.2–18.9 (15.6)	20.0	15.6	17.1–18.1 (17.6)
Pelvic-fin length	--	--	5.7–7.8 (6.8)	11.5	6.4	9.1–12.0 (10.6)
% HL						
Snout length	23.3	25.7–27.1 (26.2)	28.6–38.1 (33.6)	33.0	29.5	27.3–27.9 (27.6)

The pectoral fin is falcate in both sexes of species of *Lepidocephalus*, with the second ray being longer than the other pectoral-fin rays. However, the pectoral fin is much longer in some individuals than others, and the extent of inter- and intraspecific variation, including sexual and ontogenetic variation, is unknown. The second ray of the pectoral fin is thicker in the adult male (forming the lamina circularis) than in the female, and presumably has a function related to spawning behavior.

Some specimens of *Lepidocephalus* have a furrowed yellow pad covering the front of the snout not seen in other genera of cobitids. This pad is most obvious in Figure 1 on *L. macrochir* and *L. spectrum*. The function, and inter- and intraspecific variation, including sexual and ontogenetic, of this structure are unknown.

Key to species of *Lepidocephalus*

1. Eyes and dark pigment absent; ventrally directed tubules along lateral line; western Kalimantan *L. spectrum*
1. Eyes and dark pigment present; no tubules along lateral line 2
2. Dorsal-fin origin over pelvic-fin origin; western Kalimantan *L. pallens*
2. Dorsal-fin origin well behind pelvic-fin origin 3
3. No scales on top of head; 9 branched dorsal-fin rays; 4 branched anal-fin rays; peninsular Malaysia *L. pahangensis*
3. Scales (sometimes embedded) on top of head; 8 branched dorsal-fin rays; 5–6 branched anal-fin rays 4
4. Snout short, 3.9–5.1% SL, 23.3–27.1% HL; Java, Sumatra, southern Kalimantan *L. macrochir*
4. Snout longer, 5.6–7.4% SL, 28.6–38.1% HL; Thailand *L. nanensis*

Material examined (all measurements are mm SL). *Lepidocephalus macrochir*.—**Indonesia : Sumatra/Java** : BMNH 1866.5.2.55 (syntype, 77.7), 1 of 5 syntypes from confluence of Lamatang and Enim rivers, Palembang, eastern Sumatra, and Pepeh River, Surakarta, Java. **Borneo**—BMNH 2001.1.15.8066–8070 (4, 63.0–69.3), Kalimantan Tengah, Barito River drainage, Sungai at Desa Maruwei, 0°59.0'S, 114°44'6.0"E, 15 July 1992; BMNH 2001.1.5.8071–8075 (1, 55.9), Kalimantan Tengah, Barito River drainage, Sungai Barito at Muara Laung, 20 Feb. 1991.

Lepidocephalus nanensis.—**Thailand**—NIFI 4388 (holotype, 72.0), Thailand, Phitsanulok Prov., Khlong Chompu, Mae Nam Nan, Chao Phraya basin, Nov. 2008, G. Deein; NIFI 3787 (1, 79.3), Phitsanulok Province, Nern Ma Prang District, Chao Phraya basin, Mae Nam Nan, Khlong Chompu, Nov. 2008; NIFI 4856 (6, 69.9–76.1), Phitsanulok Province, Bang Rakam District, Mae Nam Nan, 16.76N, 100.11E, 9 Feb. 2011; NIFI 4857 (6, 68.4–80.1), boundary of Sukhothai Province, Kongkrait District with Phitsanulok Province, Prompiram and Bang Rakam districts, Mae Nam Nan, 16.76N, 100.11E, 18 Aug. 2010; NIFI 4858 (4, 56.4–67.6) Nakon Sawan Province, Chum Sang District, Borraped Lake, 15.71N, 100.27E, 11 Oct. 2010; UF 186928 (5, 68.2–75.0), Phitsanulok Province, Prompiram District, Mae Nam Nan near Naraesuan Dam, 17.04N, 100.20E, 23 Apr. 2009; UF 186929 (2, 65.5–72.7), Phichit Province, Sam Ngam District, Mae Nam Nan, 16.50N, 100.20E, 4 Oct. 2011; UF 186930 (2, 65.2–70.0), Nakon Sawan Province, Krok Pra District, Chao Phraya River, below confluence of Nan and Yom rivers, 15.55N, 100.08E, 15 Jun. 2009.

Lepidocephalus pahangensis.—ZRC 490 (holotype of *Acanthophtalmus pahangensis*, 35.8), Malaysia, off Mentakab, Pahang River, 30 May 1929.

Lepidocephalus pallens.—RMNH 7783 (holotype of *Lepidocephalichthys pallens*, 41.9), Kapuas River, presumably at Sintang.

Lepidocephalus spectrum.—USNM 230267 (1 paratype, 49.2), Kalimantan, Kapuas River opposite Silat, 0°20.5'N, 111°47'E, 17 Aug. 1976; CAS 49353 (2 paratypes, 36.0–57.4 mm SL), same as USNM 230267.

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References

- Alfred, E.R. (1970) Type specimens of fishes in the National Museum, Singapore. *Journal of the Singapore National Academy of Sciences*, 2 (2), 68–73.
- Armbruster, J.W. (2012) Standardized measurements, landmarks, and meristic counts for cypriniform fishes. *Zootaxa*, 3586, 8–16.
- de Beaufort, L.F. (1933) On some new or rare species of Ostariophysi from the Malay Peninsula and a new species of *Betta* from Borneo. *Bulletin of the Raffles Museum*, 8, 31–36.
- de Bruyn, M., Rüber, L., Nyländer, S., Stelbrink, B., Lovejoy, N.R., Lavoué, S., Tan, H.H., Nugroho, E., Wowor, D., Ng, P.K.L., Siti Azizah, M.N., von Rintelen, T., Hall, R. & Carvalho, G.R. (2013) Paleo-drainage basin connectivity predicts evolutionary relationships across three southeast Asian biodiversity hotspots. *Systematic Biology*, 62 (3), 398–410.
- Bleeker, P. (1860) De visschen van den Indischen Archipel beschreven en toegelicht. Deel II. *Acta Societatis Regiae Scientiarum Indo-Néerlandicae*, 7 (2), 1–492.
- Bleeker, P. (1863a) Sur les genres de la famille des Cobitoïdes. *Verslagen en Mededeelingen der Koninklijke Akademie van Wetenschappen, Afdeling Natuurkunde*, 15, 32–44. [Also published in *Nederlandsch Tijdschrift voor Dierkunde*, 1863, 1:380–381.]
- Bleeker, P. (1863b) Atlas ichthyologique des Indes Orientales Néerlandaises, Tome III. *Cyprins*, 3, 1–150.
<http://dx.doi.org/10.5962/bhl.title.67474>
- Fricke, R. & Eschmeyer, W.N. (2013) Guide to Fish Collections. Available from: <http://research.calacademy.org/research/ichthyology/catalog/collections.asp> (accessed 10 February 2014)
- Havird, J.C. & Page, L.M. (2010) A revision of *Lepidocephalichthys* (Teleostei: Cobitidae) with descriptions of two new species from Thailand, Laos, Vietnam, and Myanmar. *Copeia*, 2010 (1), 137–159.
<http://dx.doi.org/10.1643/ci-08-240>
- Havird, J.C., Page, L.M., Tangjitjaroen, W., Vidthayanon, C., Grudpan, C. & Udduang, S. (2010) A new species of *Lepidocephalichthys* (Teleostei: Cobitidae) with distinctive sexual dimorphism and comments on relationships in southern lineages of Cobitidae. *Zootaxa*, 2557, 1–18.
- Hora, S.L. (1941) Notes on Malayan fishes in the collection of the Raffles Museum, Singapore. Parts 2 and 3. *Bulletin of the Raffles Museum*, 17, 44–64.
- Kottelat, M. (2012) Conspectus cobitidum: An inventory of the loaches of the world (Teleostei: Cypriniformes: Cobitoidei). *The Raffles Bulletin of Zoology*, Supplement 26, 1–199.
- Kottelat, M., Whitten, A.J., Kartikasari, S.N. & Wirjoatmodjo, S. (1993) *Freshwater Fishes of Western Indonesia and Sulawesi*. Periplus Editions, Hong Kong, 293 pp.
- Roberts, T.R. (1989) The freshwater fishes of western Borneo (Kalimantan Barat, Indonesia). *Memoirs of the California Academy of Sciences*, 14, 1–210.
- Shrestha, T.K. (2008) *Ichthyology of Nepal: A study of fishes of the Himalayan waters*. Himalayan Ecosphere, Kathmandu, Nepal, 390 pp.
- Šlechtová, V., Bohlen, J. & Perdices, A. (2008) Molecular phylogeny of the freshwater fish family Cobitidae (Cypriniformes: Teleostei): Delimitation of genera, mitochondrial introgression and evolution of sexual dimorphism. *Molecular Phylogenetics and Evolution*, 47, 812–831.
<http://dx.doi.org/10.1016/j.ympev.2007.12.018>
- Talwar, P.K. & Jhingran, A.G. (1991) *Inland fishes of India and Adjacent Countries*, v. 1. A.A. Balkema, Rotterdam, 541 pp.
- Vaillant, L.L. (1902) Résultats zoologiques de l'expédition scientifique néerlandaise au Bornéo central, poissons. *Notes from the Leyden Museum*, 24 (1), 1–166.